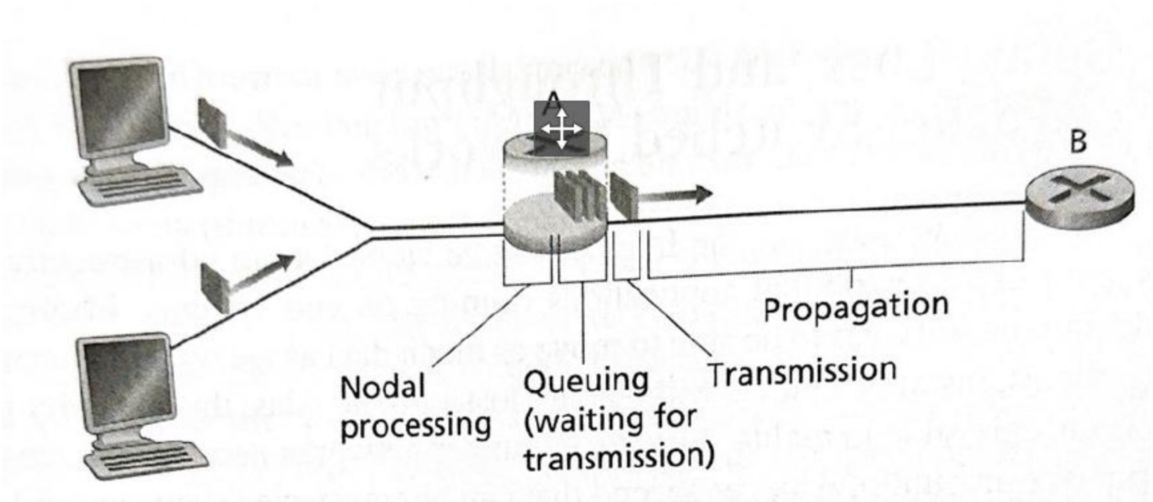


- Total nodal delay can be calculated:

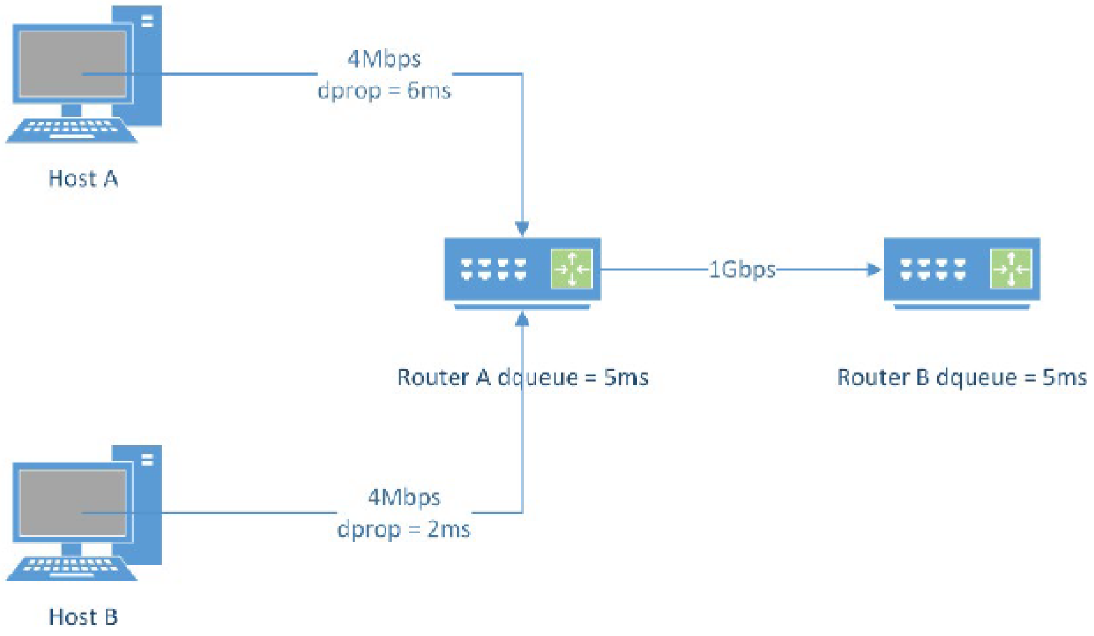
$$d = d_{proc} + d_{queue} + d_{trans} + d_{prop}$$

- Total nodal delay end-to-end:

$$d_{end-end} = N\left(d_{proc} + d_{queue} + d_{trans} + d_{prop}\right); N = number\ of\ routers\ (links)$$

Example

Consider the figure below. Assume the two hosts start to transmit packets of 1500 bytes at the same time towards Router B. Suppose the link rates between the hosts and Router A is 4Mbps and 1Gbps between Router A and Router B. One link has 6-ms propagation delay and the other has a 2-ms propagation delay from the hosts to Router A. Both routers have a queuing delay of 5-ms. Propagation delay between Router A and B is 4-ms. What is the total nodal delay end-to-end?



Example

$$d_{end-end} = N(d_{proc} + d_{queue} + d_{trans} + d_{prop}); N = number\ of\ routers$$

- Packet: 1500 Bytes
- $d_{procRouterA}$ = not specified, so assume 0. Same for Host A.
- $d_{procRouterB}$ = not specified, so assume 0. Same for Host B.
- $d_{queueRouterA}$ = 5ms
- $d_{queueRouterB}$ = 5ms
- d_{trans}:
  - $d_{transHostA}$ & $d_{transHostB}$ = Since Host A doesn't need to wait for packets in a FIFO configuration (HostA & HostB initiate transmission) then assume 0.
  - $d_{transRouterA\text{-}RouterB}$ = 1500 Bytes / 1Gbps.

- $d_{propHostA}$ = 6ms
- $d_{propHostB}$ = 2ms
- $d_{propRouterA\text{-}RouterB}$ = 4ms

Example

$$d_{end-end} = 2(d_{procA} + d_{procB} + d_{queueA} + d_{queueB} + d_{transA-B} + d_{propHostA} + d_{propHostB} + d_{propA-B})$$

$$d_{end-end} = 2\left(0 + 0 + 5ms + 5ms + \frac{1500\ B}{1Gbps} + 6ms + 2ms + 4ms\right)$$

$$d_{end-end} = 2\left(0.01s + \frac{12{,}000\ bits}{1 \cdot 10^9 bps} + 0.012s\right)$$

$$d_{end-end} = 2(0.022s + 0.000012s)$$

$$d_{end-end} = 2(0.022012)$$

$$d_{end-end} = 44.024ms$$